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ABSTRACT

Next to playing, matching instructional features with children's characteristics may stimulate children's development in early education. Instructional lines of ordered playing and learning appliances, inclusion of diagnostic and achievement indicators, flexible grouping of students, screening of initial student characteristics, and supportive software, are expected to optimize early education for students and teachers. In two Dutch kindergarten schools, instructional changes were realized in a use-oriented method by co-development with teachers and management. Also, a software prototype designed to manage and optimize early education was developed and tested. Information is given about the digital instructional management prototype, development and implementation experiences in early education, and first effects of using this software in practice. Further possibilities to optimize education in kindergarten and other educational types are discussed. (Contains 31 references.) (Author/AEF)

Designing Digital Instructional Management To Optimize Early Education

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Abstract

Next to playing, matching instructional features with children's characteristics may stimulate children's development in early education. Instructional lines of ordered playing and learning appliances, inclusion of diagnostic and achievement indicators, flexible grouping of students, screening of initial student characteristics, and supportive software, are expected to optimize early education for students and teachers. In two Dutch kindergarten schools, instructional changes were realized in a use-oriented method by co-development with teachers and management. Also, a software prototype designed to manage and optimize early education was developed and tested. Information is given about the digital instructional management prototype, development and implementation experiences in early education, and first effects of using this software in practice. Further possibilities to optimize education in kindergarten and other educational types are discussed.

Learning and instructional theories focus on individual or small-group learning, although, in school practice, learning usually occurs in the whole group or class (Collier, 1994). Within a whole group, class level learning expectancies, complexities, and norms may then interfere with small-group and individual learning possibilities and potentials. This is true in particular for learners who seem to be at risk in some respect, e.g. a learner functioning relatively low compared to most other learners (Walker, Kavanagh, Stiller, Golly, Severson, & Feil, 1998), or relatively high as specified by e.g. King, O'Shea, Joy Patyk, Popp, Runions, Shearer, and Hendren (1985).

To support development and learning processes and effects, each student's characteristics should be matched with actual instructional and didactic features (Van Merriënboer, 1997). A learner 'deviating' from the other learners may therefore profit most from instructional management designs which optimize teaching and learning for all students actually present in class. However, giving more attention to more details of learning processes requires much, and often too much, of the teacher. As differences in development and learning between children can already be rather huge at the start of kindergarten, providing adequate instruction and prevention of learning de-motivation and problems may become too complicated for the teacher (Jones, Gullo, Burton-Maxwell, & Stoiber, 1998). In this respect, Information and Communication Technology (ICT) can lend a hand (Chang, 2001; Sinko & Lehtinen, 1999). ICT consists of different kinds of electronic hardware and software which, in combination, may support the preparation, execution, and evaluation of networked teaching and learning processes and effects (Lally, 2000).

In research to explore the role of ICT in optimizing instructional and didactic management, qualitative research to model didactic and learning processes was carried out in ten Dutch secondary schools varying in background characteristics (Mooij & Smeets, 2001). Five successive phases and respective models of ICT implementation were found:

1. Incidental and isolated use of ICT by one or more teachers
2. Increasing awareness of ICT relevance for the school, at all levels
3. Emphasis on ICT coordination and hardware within school
4. Emphasis on instructional and didactic innovation and ICT support
5. Use of ICT-integrated teaching and learning, independent of time and place

After acquisition of hardware and software in phase 3, in phase 4 ICT is designed to support learning processes in more flexible and optimizing ways. In phase 5, education is being restructured from the perspectives of the learners. This process requires transformation of teaching and learning processes by changing instructional features and didactic management, in close relationship to ICT conditions supporting both individualized and small-group learning in and outside school.

Optimizing education since the start of kindergarten may be the most promising effort to prevent de-motivation and learning problems (cf. Walker et al., 1998). Therefore, the question for research is how model 5 could be designed and implemented in early education to realize the advantages potentially related to this model, in particular for students at risk. To answer this question, I will first focus on theoretically relevant instructional and management conditions to support students since the start of kindergarten (cf. Van den Akker, 1999). Next, in co-development with teachers and management, some required educational changes are realized in kindergarten practice. Then, relevant software is implemented and the user effects of this first prototype are revealed and evaluated.

Theory

Bergqvist and Säljö (1998) report about grades 1–3 of four elementary schools in Sweden. The schools use an individualized curriculum in an age-integrated classroom and the students are aged seven to nine. The researchers concentrated on student and teacher cooperation in discussing the student's weekly planning and working or, in other terms, about learning to self-regulate the schoolwork. Their observations reveal that many responsibilities are conveyed from the teacher to the student because social, pedagogical, and learning roles are intricately related to the instructional, didactic, and school-wide curriculum organization of both teaching and learning. Moreover, a student is functioning better if he or she is able to choose playing or instructional activities according to or slightly above his or her actual level of competency within a certain field. Comparable results are found by the American research of Jewett, Tertell, King-Taylor, Parker, Tertell, & Orr (1998) who concentrate on pedagogical and curricular aspects teachers have to realize to help children with special needs in kindergarten. If this matching is not realized, motivation and achievement problems may turn up for students functioning at relatively lower or higher levels of competency than their peers.

Theoretically, curricular features should be designed in such a way that concrete instructional and didactic processes are supporting each learner's activities at any time, in a positive social context. Learning could be designed also for a small group of students helping each other, or collaborating with one other (Jones, Rasmussen, & Moffitt, 1997). In this situation, the teacher's attention can concentrate more on students who most need his or her attention. Such an instructional design would require flexible instructional lines with clear diagnostics next to situations of free playing, including flexible grouping and organization throughout the educational career. On the student's side, it should be clear which competencies, and which initial levels of competencies, should be stimulated in which ways, to optimize developmental progress since the start in kindergarten.

Free Playing And Instructional Lines

In early education, free playing activities are usually based on children's own initiatives and choices (Pellegrini & Boyd, 1993). The concept of 'instructional line' can be used to refer to a specific set of learning activities ordered according to instructional difficulty level or social didactic aspects, e.g. motor behavior, social-emotional development, projects, language and literacy, (preliminary) arithmetic, (preliminary) reading, and (preliminary) writing. The line concept denotes a hierarchical arrangement of curricular concepts and sub-concepts corresponding with specific instructional or didactic play materials, representing specific learning or play activities. For example, sensorimotor development for four- to six-year-olds generally starts with global movement with the whole body, followed by movement with the arms and hands, and then by paying attention to writing conditions, e.g. direction in moving, training of regularity in movement with hands and fingers, and motor exercises evolving into preliminary writing.

Diagnostic And Progress Indicators

Within instructional lines, reliable and valid indicators need to be integrated to diagnose and evaluate learning processes and their outcomes on every student, from the start in kindergarten onwards. Monitoring is important, in particular to realize a timely promotion of the development of children at risk. Also, a standardized diagnostic or age-normed achievement test should be included. Each student's progress can then be evaluated continuously by individual, social, and age-normed diagnostic and achievement tests in the architecture of lines (cf. Byrne, 1998; Wegerif, Mercer, & Dawes, 1998).

Flexible Grouping And Organization

Making the organizational grouping of students more flexible according to learners' characteristics and instructional procedures seems another precondition to promote school careers of students at risk in particular (Bennathan & Coxall, 1998; Cooper & Ideus, 1998). Flexible grouping in small groups can for example be designed on the basis of students' competency levels, learning style, or specific didactic preferences or requirements in case of certain handicaps. Moreover, flexibilizing of students' grouping can also stimulate cooperation between professionals in and outside school, to support children better than in their earlier development (Mangione & Speth, 1998).

Screening Of Children's Entry Characteristics

Close observation and analysis of interactions between instructional features and students' learning characteristics reveal that development and learning problems may start early in kindergarten (Skinner, Bryant, Coffman, & Campbell, 1998). Given the differences in development between children already at the very start of kindergarten, it is important to present adequate and diverse kinds of playing and learning materials. This is most relevant for children deviating most from the other children in class. To get relevant information as soon as possible, it is helpful to screen a child's starting characteristics by parents at intake, and by the class teacher after the child's first month in school. Communication about differences between the perceptions of parents and kindergarten, and taking adequate curricular action if indicated, can prevent motivational, social, emotional, or cognitive problems of vulnerable students in particular. The teacher or another professional can additionally diagnose or assess characteristics, and assign specific playing and instructional activities to a child or a small group of children, if possible in cooperation with parents. Guidelines to this optimization process are presented and discussed by Mooij, Terwel, and Huber (2000).

Software Features

Initially, it is not clear how software could be designed to support the optimization possibilities sketched above. For this reason, it was decided to first start the developments sketched above in kindergarten practice. In doing this, it could be checked in how far design features of the software could be based upon educational features, and how their specifics had to be to help teachers. At the same time, implementation and first effects of the software could be observed.

Method

The theoretically desirable educational features were not known to exist in practice. Therefore, a developmental project was planned in two regular Dutch kindergartens for children aged four to six. The usual planning system in these kindergartens consisted of a planning board on the wall, with a differently colored column for each day of the week. Small groups of students, corresponding with certain table groups, were indicated by different logos and colors. Activities to be done by a small group were assigned by placing the tags of these students on a logo representing a certain kind of activity, on a certain day of the week, on the planning board.

In the years 1997–2000, teachers, management, and the researcher collaborated to develop instructional lines based on the regular playing and learning appliances in the kindergarten classes. Recent methodology supports a strategy in which users, for example teachers and school staff, collaborate with researchers and other specialists to secure validity of innovation processes (cf. Blumenfeld, Fishman, Krajcik, Marx, & Soloway, 2000; Clark & Estes, 1999; Kensing, Simonsen, & Bødker, 1998). Wilson (1999) expects that 'use-oriented' strategies '(...) increase the likelihood of successful implementation because they take the end use into account at the beginning design stages' (p. 13). This development co-occurred with flexibilization of grouping of students, and the screening of students' entry characteristics by parents and the class teacher.

In the first period, attention was focused on rearranging and registering the appliances to clarify the instructional and didactic aspects of the playing and curriculum system. Next, the use of the registered appliances either by the teacher or by self-management of the students was made concrete. Parallel to this, and in the same collaborative way (cf. Ely, 1999), a first prototype of a computer program was designed and developed. The design concentrated on extending optimization features and possibilities of the planning board, to better assist teachers and students (Crook, 1998). Essential software functions of this 'digital instructional management' were related to registering and manipulating information about instructional lines, students and teachers, and promoting students' instructional self-management. The information from educational practice was collected into digital databases within the framework of a standalone computer.

Results

Software Features

Information on Instructional Lines. A first main feature of the prototype is the creation, change, or removal of an instructional line. Lines developed refer to, for example, motor behavior, social-emotional development, projects, language, (preliminary) arithmetic, (preliminary) reading, and (preliminary) writing. Each instructional line in kindergarten class and, correspondingly, in the software, is characterized by a specific logo, a specific color, and a corresponding name or text. Activities or tasks within each line are visually represented by a photograph of the object as present in class because four-year-olds must be able to work with the program. A screenshot of this feature of the prototype is given in Figure 1.

A second main feature concerns the input, change, or removal of activities or tasks within specific levels of an instructional line. Within a line, activities or tasks are ordered by difficulty level. To stimulate students adequately, variants of lines referring to different developmental levels were constructed for e.g. 'normal' students developing in a more or less regular way, students requiring special or remedial activities, and highly able students who are advanced on the topic of the line. Moreover, an activity can be tagged with an indicator meaning that the student has to go to the teacher in order to continue. For example, an indicator may mean that a student's initial level of language competency has to be screened, as a basis for further support and placements. In the same vein, a standardized diagnostic or achievement test can be included, in particular for measurement with a conspicuous student or a student at risk. Another potential use is the formation of a small group of students by the teacher, to do the tagged activity. A screenshot of ordering an activity by using a photograph, name, and description into an instructional language line at level 6 is shown in Figure 2.

Figure 1. Symbols (Logo, Color, Name Of Line) Representing Four Instructional Lines

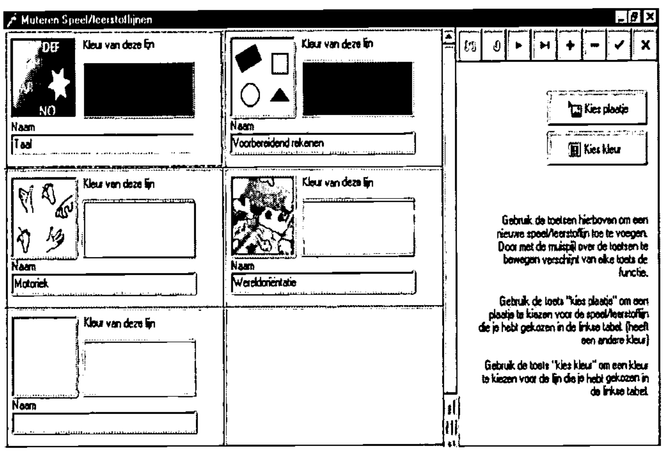
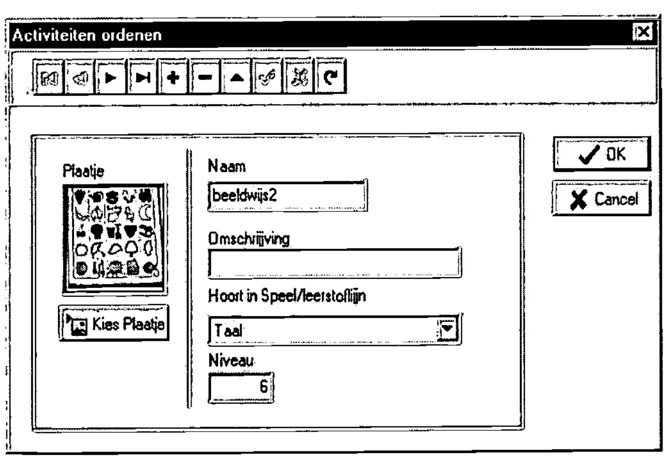


Figure 2. Ordering Of Activity (Photograph, Name, Description) Into Instructional Line And Level

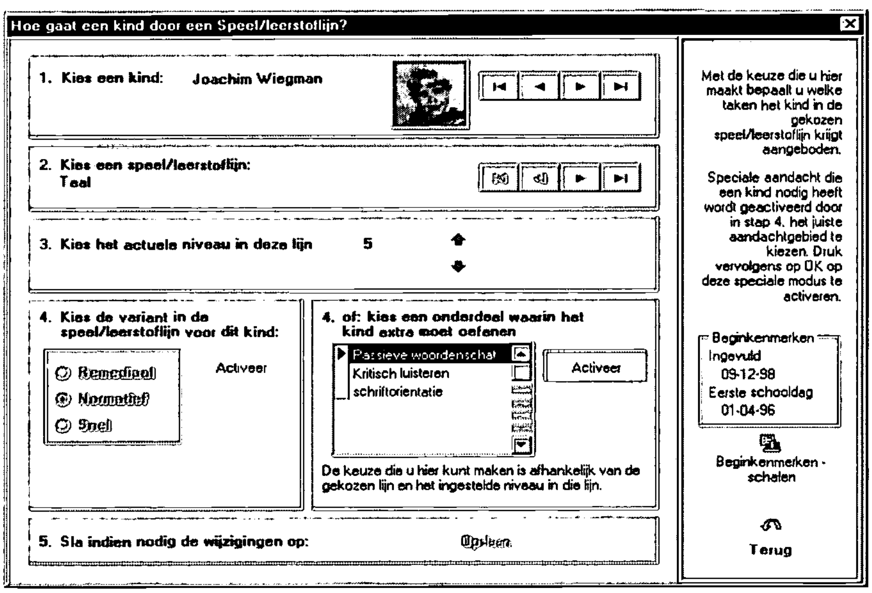


A third feature of the software is the possibility to get an overview of the content of an instructional line, or a set of variants of an instructional line, at a specific level of difficulty.

Information about Students. Another main feature of the software has to do with registering administrative information about a student: adding a new student, removing a student, or changing existing information about a student. For example, the teacher can register students by integrating their photographs in the database. The photographs of all children in one class can be shown in one screen. Furthermore, the registering of each student's initial characteristics is carried out in conformance with a psychometrically controlled procedure based on quantitative longitudinal research with 966 four-year-olds (Mooij, 2000). An overview of initial characteristics of a student, and a comparison between the information from parents and teacher, can be produced automatically.

A second main feature here is placing a student within an instructional line. Teachers can insert and order pictures of didactic activities or materials, and assign different activities to different students. A screenshot of these possibilities is given in Figure 3. This figure shows that a teacher can successively select a child (see Program Line 1 with the photograph of the student), select a kind of instructional line (2), the actual difficulty level of this line (3), the variant of the line for the student (remedial, regular, fast, or some specific material: see 4), and finish by saving the changes made (5). The next time this boy accesses the computer software, his choices to play or work are determined by the teacher's instructional management decisions. In this way, the student's choices and consequent activities are regulated by the digital instructional management system. It should be noted that the student is not working on the computer to complete activities, though teachers can of course decide to include this possibility as one of the alternative instructional lines.

Figure 3. Placing A Student Into An Instructional Line, With Level And Other Specifics



Third, the software allows automatic logging of activities for each of the students working with the software.

Information about Teachers. Here the most important facilities refer to adding a new teacher to a specific class, removing a teacher, and changing existing information about a teacher.

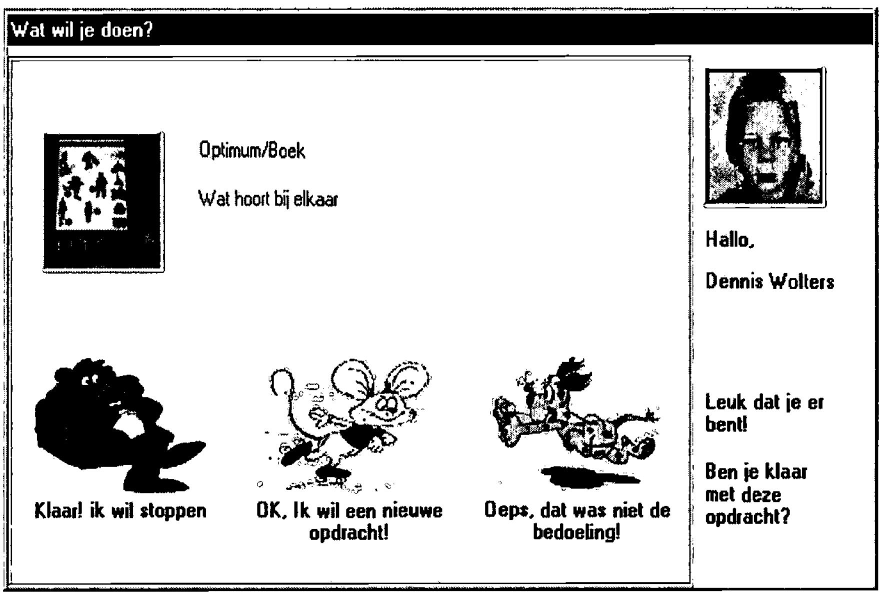
Students' Instructional Self-Management. A student can click his or her own photograph on the screen that contains all the photographs of the students in class. What the computer screen then looks like is shown in Figure 4. The screen shows the photograph and the name of the student (top-right corner). The top–left corner presents the object or material that the student is actually working on. The three icons at the bottom of Figure 4 each illustrate one possibility: the student is ready and wants to stop with this task (left icon), the student wants to select a new activity (middle icon), and the student made a wrong choice and goes back one decision (right icon). Using this interface, the student has to know which virtual assignment corresponds with which real playing or instructional activity in the classroom. Of course, a student can be helped by another student or by the teacher.

Children usually play or work with the real three-dimensional materials, and not on the computer. This feature seems to suit children of this age best, and it also overcomes computer access constraints. Moreover, a teacher can change or extend playing or other structured activities within a line, to improve the educational processes or to check their desired effects on one or more students.

Functioning Of The Prototype

Implementation and Effects in Kindergarten Practice. First of all, by using the prototype the teachers discovered that their playing and learning activities and materials needed acute extension. This insight was based on the screening of the students' initial competencies by the parents and the class teacher, and the subsequent need to integrate the different levels of initial competence into adequately differentiating playing situations and instructional lines. The differences between their students were much bigger than was accounted for in the available activities, appliances, and materials. A clear consequence was that a great deal of the school budget was spent on buying new playing and learning materials.

Figure 4. Screen Showing The Alternatives Reflecting A Student's Self-Management



Second, teachers learned pedagogically and instructionally relevant relationships between the characteristics and activities of the children, and the use of playing and learning materials and appliances in kindergarten. According to the teachers, this enabled them to use the materials to promote the functioning of the students much better than before. However, teachers took much more time than before to instruct the students. Since the class size (25–30 students) imposed severe time restrictions, the time problem was resolved by calling in parents to instruct specific students. This was not really satisfying. Much more teacher assistance seems needed to adequately integrate student differences present at the start of kindergarten. The software thus highlights that there may be more work than only one teacher in a class can handle.

Third, some of the students of four, five, or six years old learned to get along with the program very soon. They could assist other students too, if necessary. Some of the students had more difficulty in using the program. Because students' self-management was clearly stimulated by the software, the teacher's opportunity to devote more time to the students who needed this assistance most, was enlarged.

Finally, a main experience of all persons involved in the development was that the co-development of curriculum, learning, and ICT conditions in practice started a learning process for all (cf. Remillard, 2000). The collaboration between teachers, management, research, and software developers, according to a use-oriented design, proved to be very worthwhile.

Potential to Optimize Instructional Management. The first prototype in kindergarten suggests more possibilities of software to optimize instructional and didactic management processes. Instructional lines can function as main vehicles to explicitly define, integrate, and evaluate curricular features and processes, diagnostics and specific assessments, and learning processes, at different educational levels simultaneously. In addition to ordering and presenting instructional lines, ICT can help to diagnose and assess each student's progress in both individual and group-normed ways, and to construct specific instructional lines for marginal students or students at risk, if necessary in collaboration with external specialists. ICT can also support networked instructional and didactic management for various types of users at different levels of the educational system, e.g. students, teachers, school administration and school management, and external professionalists (see e.g. Tymms, Merrell, & Henderson, 2000). An exp lorative overview of relevant levels, potential users, and optimization functions of ICT, is given in Table 1.

Table 1. Optimization Functions Of ICT At Various User Levels

Users / High-Low Educational Levels	*Optimizing Functional Features of ICT*
Policy / Development / Research	Collect and evaluate data from (interactions between) curriculum and learning at all levels. Plan, coordinate, develop, evaluate quality aspects and optimization of curriculum / learning.
Regional Instances (e.g. School Psychologists, Advisors, Youth Aid, Municipal Policy)	Aggregation of in -school data to data at regional level and regional developments. Plan, coordinate, develop, evaluate quality aspects and optimization of curriculum / learning. Develop and evaluate qualitiesof regional features relevant to curriculum / learning. Develop, evaluate optimization of curriculum / learning re. students and specific students at risk. Collaborate with school / location management, teachers, students, and parents.
School Board, Management, Staff	Analysis of curriculum / learning data re. unit / location / school level and developments. Plan, coordinate, develop, evaluate quality aspects and optimization of curriculum / learning. Develop, evaluate optimization of curriculum / learningre. students and specific students at risk.
Teachers	Analysis of curriculum / learning data re. student / (small-) group level and developments. Plan, coordinate, develop, evaluate quality aspects and optimization of curriculum / learning. Develop, evaluate optimization of curriculum / learning re. students and specific students at risk. Complete / change / output indicators re. level-specific curriculum and student characteristics. Complete / change / output indicators re. instructional lines and groupings for student(s). Complete / change / output (normed) indicators on individual and group achievement.
Parents	Completion of initial and other competencies of their own child. Overview of their child's developments and progress ('virtual portfolio').
Students / Learners	Automatic logging and storing of activities chosen, and logging of processes and results. Select actual or next instructional line, and actual or next activity. Plan, coordinate, develop, evaluate quality aspects and optimization of curriculum / learning.

Integration of Diagnostic and Achievement Evaluation. The evaluation of the prototype also suggests the specification of three kinds of activities within an instructional line: regular activities, evaluative activities, and normed activities. Normed diagnostic and achievement indicators in instructional lines are defined as representing a generally valid kernel structure of pedagogical-didactic features of the curriculum. This kernel allows a structured diagnostic evaluation of a child's characteristics and progress in individual, social or group, and normed respects, in the course of time. Such a multidimensional evaluation scheme is needed to provide a complete responsible stimulation of the development of a child, from the start in kindergarten onwards. Moreover, the kernel structure can be changed locally or extended into local instructional lines which better fit situational teaching or learning conditions, as long as the normed referents in the lines are kept intact. The same or comparable indicators can be used as a common frame of reference for the preventive commitment of external specialists like a school psychologist (cf. Griffin & Beagles, 2000).

Discussion

In a four-year project, attention was focused on the improvement of early educational practice in kindergarten. To this end, instructional lines with respect to ordinary playing and learning appliances were co-developed with teachers and management. Ordering of instructional, didactic, and diagnostic materials occurred with symbols (logo, color, names) to make them concrete for young children. Also, software was developed and used in two classrooms to check their functioning in educational practice.

The results can be summarized as follows. First, starting characteristics of each student are measured and discussed systematically by parents and teacher. Problems or risk characteristics can get more systematic and preventive pedagogical attention, if necessary by early inclusion of specialists outside school. This means that preventive cooperation between parents and kindergarten teachers can increase considerably in comparison with current practice in early education.

Second, next to the usual free-playing and whole-group sessions, each student can now get systematic and immediate curricular support at his or her own levels of competency. Controlled specific support can become available for the students who need this. Also, automatic logging and monitoring of student and class or school results becomes available, which is not dependent on only one teacher or small group of teachers.

Third, the software allows a growth in the independence, self-regulation, and self-responsibility of the students, which is also possible because the students themselves can assist each other in communicating with the computer. This advantage will increase when the students get older.

Fourth, specific operationalization of e.g. giving equal opportunities to students from ethnic minorities, introducing quality standards in education, or increasing safety at school becomes possible. Here, systematic innovation support will be needed in the developing kindergartens and schools. In the long run, the software can act like a supportive planning and instructional management system for teachers, students, the school, the school board, and the parents alike.

Fifth, though quantitative data are not yet available, the hypothesis seems legitimate that the use of digital instructional management in early education will stimulate the optimization of educational processes and outcomes. Compared with traditional early education, more prosocial and constructive learning processes can be realized in practice, in collaboration between teachers and school staff, students, parents, and specialists from outside school but working within the framework of the same instructional lines and progress evaluation. Quantitative research to verify this hypothesis for students at risk in particular should be designed, but until now research facilities are only present for developmental follow-up projects. A first project in early and primary education concentrates on developing the pedagogical-didactic kernel structure, as defined above. Moreover, implementation in practice co-occurs with development and implementation of a second prototype of the digital instructional management system. The design of this Internet-based software is specified on the outlines given in Table 1.

A second follow-up project is carried out in secondary education. First, local instructional lines are developed and introduced in school practice. Teachers develop these lines within a self-chosen project on 'Water and environment', for small groups (2–4) of students. To aid the self-management of students, teachers create activity worksheets for each activity within the instructional lines. The worksheets contain aspects of preparatory instructional specifics, the actual performance, and the evaluation of project activities. Curriculum and learning materials are present in or around the classroom, school library, or the Internet. The worksheets provide instructional information about learning processes, materials and sources, appliances that can be used, and diagnostic evaluation. Evaluation and judgment become more individualized, but reliable or valid achievement indicators or norms hardly exist at present. Development of such indicators will become possible by authoring Internet-based software, comparable to the second prototype for early education. This prototype for secondary education is now under development.

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